A Simulation Model For the Analysis of A Combined Heat And Power Consumer with Variable Consuming Pattern

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The problem

An industrial consumer (airport, chemical or industrial plant, hospital, city etc.) needs a variable quantity of heat and power for its good functioning. Usually it purchases the power from the grid or direct from a certain supplier (utility company, independent power producer etc.) at a variable price, depending of the moment of purchase and of the moment of ordering it. The heat, in the form of technologic steam or hot water can be also purchased from a provider, in the same conditions of variable price, or can be produced locally.
The need for power and heat is not constant, even for a constant process, due to the daily, weekly and annual variations imposed by the natural conditions. Even if it is desired to have a constant process, the reality is far from this and a number of contingent situations may occur, each of them with a different probability. Current developments indicate the tendency of developing distributed power generation units especially on those sites with high consumption and a relative small area, with additional heat consumption and with a relative constant level during the year. The reason is pure economical, the costs associated with this distributed generation being lower in many cases, due to recent developments in power generation technology. This solution of producing itself the power and heat is extremely attractive with only one condition: reliable model accuracy.

Solutions

Almost all feasibility studies consider the case of a constant consumption, at an average value for one whole year. If the decision to build and own a facility for generating power and heat is taken, a general tendency is to dimension it to cover the maximum need. The true results during time differ from calculations.

Computer simulation model

A model of the consumer was made considering the influential factors: time, ambient conditions, level of production etc. The costs with energy were calculated considering the tariffs and prices charged by the suppliers, taxes and other surcharges. The scenarios are: most probable, low production, high production. Other scenarios may be considered: continuous production, batch production, one to three shifts, weekend shifts etc. The model is designated to demonstrate the cost/benefit of various scenarios and to be a management tool in decision making in long term planning of a major heat and power consumer.
From this analysis the results of a number of scenarios can be visualized, conducting to better decisions in managing the power and heat consumption and supply for our unit.
This model, correlated with one of a combined power and heat generating facility, may be a management tool with more accurate solutions in analyzing combined heat and power consumers. It can be useful in cost optimization in the potential power supply mix, with an emphasis on the opportunity of build, own and operate a suitable combined power and heat generating unit.
The benefit of this tool is its flexibility in analyzing particular scenarios, with easy visualization and interpretation of the results.

- cost optimization of the available generation mix sources
- reduced dependence of the grid supply
- improved grid reliability
- improved generation efficiency, with secondary effects on environment pollution and global warming

The consumer:

Seasonal power and heat load:

$$p = p(w, d, h) = p(w) * p(d) * p(h)$$
$$P_{w,d,h} = p(w) * p(d) * p(h) * P_{med}$$

$$P_{year} = 8760 * P_{med}$$

$$P_{week}(w) = 168 * pw(w) * P_{med} = pw(w) \frac{P_{year}}{52.143}$$

$$P_{day}(d, w) = 24 * pw(w) * pd(d) * P_{med} = pw(w) * pd(d) \frac{P_{year}}{365}$$

$$P_{hour}(h, d, w) = pw(w) * pd(d) * ph(h) * P_{med} = pw(w) * pd(d) * ph(h) \frac{P_{year}}{8760}$$

fi = unsteady factor
k=1-fi*(1-kf); fi=1 for present, fi=0 for total constant pattern, fi>1 for a more unsteady pattern